Aglenchus ainakamurae n. sp. and Records of *Cephalenchus leptus* and *Lelenchus leptosoma* from Japan (Tylenchida: Tylenchidae)

Takayuki MIZUKUBO*

Three species of Tylenchidae, *Aglenchus ainakamurae* n. sp., *Cephalenchus leptus leptus* and *Lelenchus leptosoma* are reported from Japan. *Aglenchus ainakamurae* n. sp. collected from soil around the roots of *Zanthoxylum piperitum*, *Acer palmatum*, *Lespedeza* sp. and *Urtica* sp. in Mt. Gozenyama, Ibaraki, Japan is described and illustrated. It can be distinguished from closely related *A. muktii* by the absence of males, a hair-like tail terminus, and a tapering head profile. *Aglenchus muktii* apud GERAERT and RASKI nec PHUKAN & SANWAL, which is renamed *A. geraerti* nom. nov., also differs from *A. ainakamurae* by the presence of males, an offset head profile, number of body annules, MB-, c-, V- and V'-values. *Cephalenchus daisuce* is ranked as a subspecies of *C. leptus, i.e. C. leptus daisuce,* based on a study of the variability and the correlations between some measurements in Japanese *C. leptus* populations. It is also suggested that *C. limichus* should not be synonymized with *C. leptus*. Populations of the nominated subspecies *C. leptus leptus* that is described and illustrated were collected from soil around the roots of *Acer mono* var. *marmoratum,* a herbaceous plant and an unidentified tree. Populations of *L. leptosoma* from forest soil are first records of this species in Japan, and are measured and figured. *Jpn. J. Nematol.* **19** : 18-31 (1989).

Despite the fact that the long tails in some species of Tylenchidae are often the source of confusion in taxonomy, the length of tails and related c- and V-values have been used as diagnostic characters. GERAERT[2] showed that very long tails of some tylenchids behaved differently in relation to head-anus distance and the use of ratio-c depended on the nematode.

Many nematode species have been distinguished largely by the morphometrical gaps rather than qualitative differences, but few morphometrics have been tested. Some genera of Tylenchidae have been revised on several occasions[1, 3, 5, 8, 9], and this, to some extent, makes it possible to analyse the differences between several populations. The objective of the present work was to identify the long-tailed species of the genera *Aglenchus, Cephalenchus* and *Lelenchus* from Japan, using statistical analyses of the morphometrics including tail length. Some species are revised based on the results. Specimens examined were killed by gentle heat, fixed by TAF, and mounted by the method of SEINHORST[10].

Morphometrics of *Aglenchus* species

Using a Japanese population of *Aglenchus* sp., correlation analyses were conducted on the ratios c, MB, V and V' and a regression line of VL on L' was determined. Results are as follows: 1) Correlation between tail length and length of body trunk (L') (ratio-c) is positive and significant ($r=0.582$, $p<0.01$, n=30); 2) Correlation between distance of esophageal length and distance from anterior end to valve of metacorpus (ratio-MB) is positive and significant ($r=0.806$, $p<0.01$, n=31); 3) Correlation between VL and L (ratio-V) is positive and significant ($r=0.881$, $p<0.01$, n=30); 4) Correlation between VL and L' (ratio-V') is strongly positive and

* Laboratory of Nematology and Soil Zoology, Division of Microbiology, National Institute of Agro-Environmental Sciences, Kannondai 3-1-1, Tsukuba, Ibaraki 305, Japan.

Table 1. Comparison of *Aglenchus muktii* populations and *A. ainakamurae*

Criteria	*A. muktii**	*A. muktii***	*A. ainakamurae*		
	range	range	range	mean±SD	C.V.(%)
n	14	7		30	
L (μm)	525−620	620−715	575−671	(628±22)	3.5
c	2.5—3.1	2.9—3.4	2.5—2.8	(2.6±0.07)	2.5
MB	47.5##	43−46	46.1−50.0	(48.2±1.0)	2.2
V	46−53	52−56	46.0−50.4	(47.8±0.9)	1.9
V′	75.7##	78−82	74.5−79.1	(77.4±0.93)	1.2
D.G.O. (μm)	1.5−2.5	—	0.5−1.3	(0.9±0.27)#	26.7
spear (μm)	11−13	10.5−11.5	11.9−13.2	(12.5±0.28)	2.2
Rex	40##	—	31−37	(34±1.6)	4.7
ROes	47##	50−62	38−47	(42±2.3)#	5.5
RV	—	204(n=1)	160−178	(168±5.4)#	3.2
R-an	—	267(n=1)	212−235	(222±7.1)#	3.2
tail tip	rounded	effilate (not rounded)	hair-like/needle-like		
head(lateral)	offset/balloon	offset/balloon	continuous/tapers to apex		
male	present	present	absent		

* PHUKAN & SANWAL (1980).
** GERAERT & RASKI (1988).
\# n=15.
\## calculated from drawings.

significant ($r=0.958$, $p<0.01$, n=32). The regression line of VL(Y) on L′(X) is Y=−12.274+0.806X.

These results show that MB- and V′-values are very useful to characterize this population. The V-value and even the c-value can be used in the taxonomy, although GERAERT[2] did not obtain any positive correlation for c-value in *A. agricola*.

GERAERT & RASKI[3] provided the figures and the dimensions of an *Aglenchus* population from California identifying it as *A. muktii* PHUKAN & SANWAL, 1980[7]. In my opinion, they are not conspecific. From the comparison of measurements of *A. muktii* (Table 1) it is apparent that V-values hardly overlap one another, in addition to difference in body length, the only difference noticed by GERAERT & RASKI. Further differences can be listed as: V′-value (75.7 *vs.* 78−82), MB-value (47.5 *vs.* 43−46) and tail terminus. The latter of the original description[7] is rounded, whereas the tail terminus of the Californian population is apparently not rounded. Such ratios as V, V′ and MB may provide a good yardstick to distinguish species in *Aglenchus*, since they show rather low coefficients of variability (C.V.) when the mean and SD are presented. This is apparent from the data of *A. agricola* and *A. dakotensis* (GERAERT & RASKI[3]) and is supported by the above results of *Aglenchus* sp. from Japan, which is described below.

Based on these differences the Californian population can be distinguished from *A. muktii*, and is renamed as:

Aglenchus geraerti nom. nov.

Syn. *Aglenchus muktii* apud GERAERT & RASKI, 1988 nec PHUKAN & SANWAL, 1980.

Aglenchus ainakamurae n. sp.

(Fig. 1 A-I)

Holotype (*female*): L=653 μm; L′=399 μm; a=40; b=7.4; c=2.6; c′=25.7; V=47; V′=78; spear=12.9 μm; MB=48; G1=18; Tail/V-a=2.9.

Paratypes (*females*, n=30): L=628 μm ±22 (575−671); L′=390 μm ±14 (355−420); a=

37.1±3.8 (30.7−48.4); b=7.2±0.34 (6.5−8.0); c=2.63±0.07 (2.5−2.8); c′=23.3±2.41 (17.6−27.2); V=48.0±0.92 (46.0−50.4); V′=77.4±0.93 (74.5−79.1); spear=12.5 μm ±0.28 (11.9−13.2); MB=48.2±1.04 (46.1−50.0); G1=19.1±3.40 (15.3−26.9); Tail/V-a=2.7±0.15 (2.4−3.0).

Description: *Female* (n=30): Body slightly bent ventrally when heat relaxed, very slender, of equal width from esophageal end to vulva then evenly tapers to tail terminus (Fig. 1 A). Maximum body diameter 17.0 μm±1.6 (13.9−21.5), 2.8 times±0.25 (2.3−3.6) of head diameter. Body annules wide, 2.2 μm±0.11 (1.9−2.4) at the region of median bulb, 1.6 μm±0.13 (1.3−1.8) at mid-body. Average width of body annules throughout the body excluding tail 1.78 μm±0.07 (1.67−1.89) (n=15). Number of annules counted as follows: 34±1.6 (31−37) for Rex, 42±2.3 (38−47) (n=15) for ROes, 168±5.4 (160−178) (n=15) for RV, 54±3.0 (49−61) (n=22) for RVan and 222±7.1 (212−235) (n=15) for entire body annules excluding tail (R-an) respectively. Lateral fields protruded, 4.0 μm±0.47 (3.3−4.6) (n=13) wide, 24.3 % (20.8−27.5) (n=13) of corresponding body diameter; in lateral view inner line often indistinct but single incisure is recognizable, thus there are three incisures.

Lip region of medium height, 3.3 μm±0.21 (3.0−3.6) high, 6.1 μm±0.21 (5.6−6.4) wide, continuous with body contour, tapers toward truncate apex in lateral view (Fig. 1 B, C), while in dorso-ventral view, the heads somewhat balloon-like and is distinctly set off from the neck (Fig. 1 D). Lip striation hardly visible. Labial framework distinct, arched. Spear slender, 2.1 times± 0.07 (1.9−2.2) as long as head width; conus 49.4 %±2.25 (42.1−52.6) of entire spear, nearly as long as shaft; knobs well developed, 3.2 μm ±0.17 (2.8−3.4) wide, broadly rounded (Fig. 1 B-D). Dorsal gland orifice (D.G.O.) close to spear base, 0.9 μm (0.5−1.3) behind. Cephalids about the third and the seventh body annule behind lip.

Esophagus 87 μm±3 (81−94). Procorpus 2.2 times±0.3 (1.7−2.6) of spear length. Median bulb oval, 10.0 μm±0.95 (8.6−10.9) (n=15) long, 6.6 μm±0.73 (5.6−8.3) (n=15) across, 1.5 times±0.15 (1.3−1.9) (n=15) as long as wide; valve conspicuous, 42 μm±1.7 (39−47) from anterior body end, at about half total length of esophagus. Isthmus 24 μm±1.7 (22−28) (n=20), 1.5 times±0.17 (1.3−2.0) (n=20) as long as basal bulb, which is pyriform 16 μm±1.2 (14−18.5) (n=20) long. Excretory pore in the vicinity of frontal margin of basal bulb, 71 μm±1.8 (67−75) from anterior body end or 81.1 %±3.14 (75.0−88.6) of esophageal length; hemizonid immediately anterior to excretory pore, 1 to 1.5 annule long. Deirids between two annules before and two annules behind excretory pore.

Vulva sunken in body; vulval flaps well developed, minutely crenate on margins (not figured), 5.9 μm ±0.7 (5.0−7.3) (n=21) long (Fig. 1 E-H). Vagina thick walled and constricted at base, strongly inclined anteriorly, 6.7 μm±0.84 (5.3−7.9) (n=15) long, without post-uterine sac (Fig. 1 E-H). Gonad outstretched, 121 μm±22 (95−175) long; oocytes arranged at least partially in double row. Spermatheca mostly indistinct, at 47 μm (38−56) (n=6) anterior to vulva, empty (Fig. 1 E). Phasmids difficult to see. Rectum nearly as long as anal body diameter (Fig. 1 I). Vulva 88 μm±4.5 (79−100) distanced from anus. Tail 239 μm±10.9 (205−254), evenly tapers to hair-like or rarely needle-like tip, never rounded as in *A. muktii* (Fig. 1 J).

Male: Unknown.

Type material: Collected on May 19, 1989 by Mrs. Ai NAKAMURA after whom the species is named.

Holotype (female: Type No. 27-1) and paratypes (50 females, 10 juveniles) are deposited at the Herbarium and Insect Museum of the National Institute of Agro-Environmental Sciences (NIAES), Tsukuba City, Ibaraki, Japan.

Type host: *Zanthoxylum piperitum* DC.; *type locality*: Mt. Gozenyama, Gozenyama-mura, Ibaraki, Japan.

Other host: *Acer palmatum* Thunb., *Lespedeza* sp. and *Urtica* sp.; *locality*: same data as type locality.

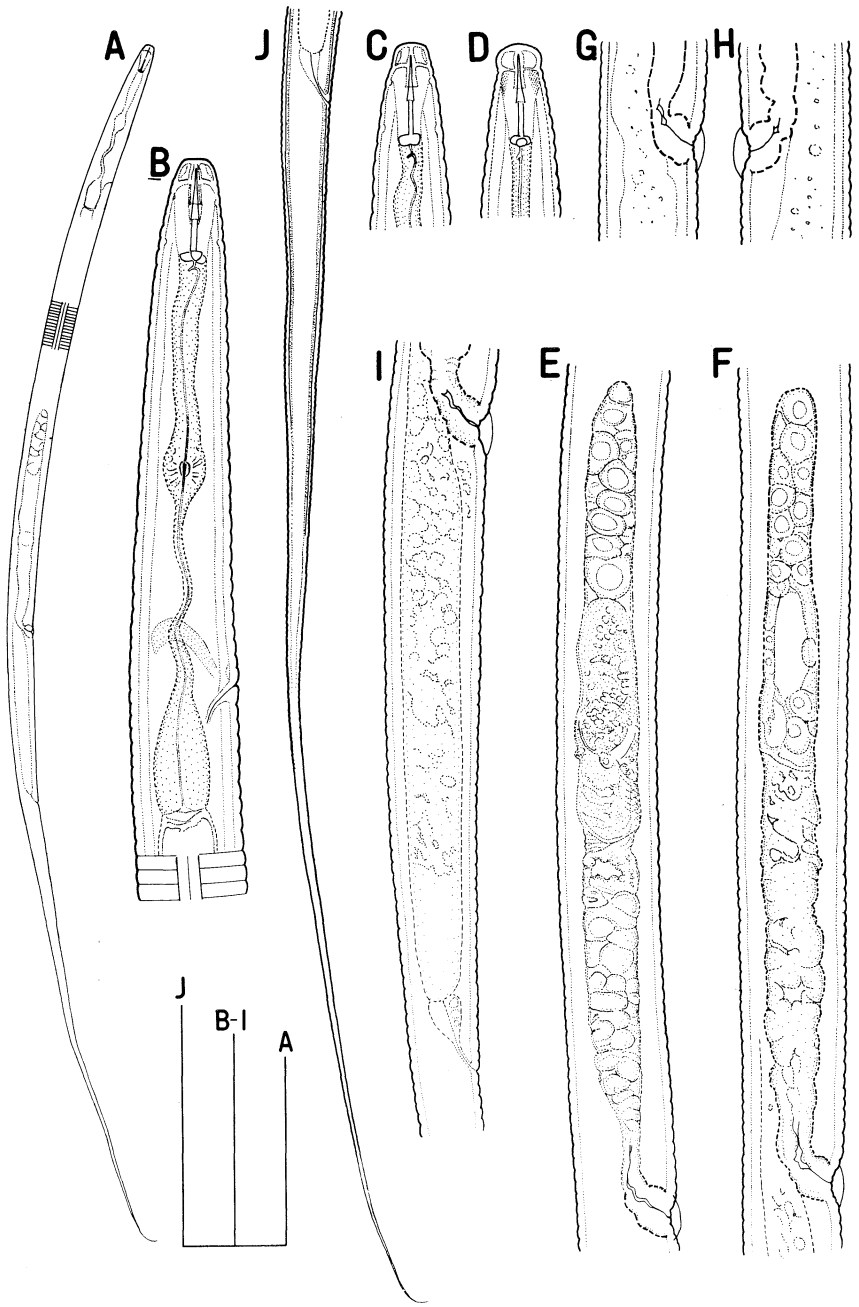

Fig. 1. *Aglenchus ainakamurae* n. sp. female. A, full length; B, esophageal region; C, cephalic region in lateral aspect; D, *do* in dorso-ventral aspect; E-F, gonads; G-H, vulval region; I, vulva-anus region. Scales: A, 100 μm; B-I, 30 μm; J, 50 μm.

Diagnosis and relationships: *Aglenchus ainakamurae* n. sp. is a parthenogenetic species characterized by the long filiform tail and three incisures in the lateral fields. Its head is unique because of its narrow and continuous profile in lateral aspect, but when oriented dorso-ventrally, the head is balloon-like and is constricted at the neck misleading observers to *Cephalenchus* species. Most morphometrics of this species agree well with those of *A. muktii*[7]. However, it differs from *A. muktii* by the absence of male (indistinct spermatheca in females), short distance of D.G.O. (0.7−1.3 μm *vs.* 1.5−2.5 μm in *A. muktii*), hair-like or rarely needle-like tail terminus and lateral profile of head (hardly offset and tapers to apex *vs.* offset and somewhat balloon-like). It differs from *A. geraerti* nom. nov. by the MB (46−50 *vs.* 43−46), c (2.6−2.8 *vs.* 2.9−3.4), V (46−50 *vs.* 52−56), V′ (75−78 *vs.* 78−82), profile of lip region, and decidedly fewer number of annules in body regions (Table 1).

Morphometrics of *Cephalenchus leptus* and related species

A. Ratios analyses:

(1) *Correlation related to ratio-b*: Correlation analysis of esophagus length and body length shows low correlation coefficients ($r=0.0275$, $p>0.05$) for population from Hokkaido (n=29). This means that esophagus length is independent of body length, and the b-value is meaningless as a taxonomic character so far as *C. leptus* is concerned. This also agrees with the observation of GERAERT[2] that b-value had no meaning in several tylenchid species.

(2) *Correlation related to ratio-c*: By regression analyses of tail length (Y) on body length excluded tail(=L′) (X) in Japanese *C. leptus* and *C. daisuce* populations, I have obtained the following:

(A) $Y=147.6\pm0.181X$, $r=0.414$, $p<0.05$ (*C. leptus* from Hokkaido: n=31)

(B) $Y=115.4+0.250X$, $r=0.557$, $p<0.05$ (*C. leptus* from Nagano: n=18)

(C) $Y=-30.4+0.527X$, $r=0.555$, $p<0.05$ (*C. daisuce*: n=18)

These positive ($p<0.05$) correlation coefficients support the observation of a slightly lower C.V. in c-value (4.5(A), 4.1(B) and 6.3(C)) in comparison with those in tail length (5.8(A), 6.0 (B) and 10.8(C)). No significant difference is present between the correlation coefficients at the 95 % level.

The difference between the regression coefficient of the three population was tested by a *t*-test with:

$$t=\frac{b_1^{(A)}-b_1^{(B)}}{\sqrt{(1/S_{xx}^{(A)}+1/S_{xx}^{(B)})(S_e^{(A)}+S_e^{(B)})/(n^{(A)}+n^{(B)}-4)}}$$

where S_e, b_1 and n are the residual sum of squares, regression coefficient and number of observations respectively. The degrees of freedom are $n^{(A)}+n^{(B)}-4$. Results are as follows: a) $t(A*B)=0.571<t(46, 0.05)=2.013$; b) $t(A*C)=1.886<t(46, 0.05)=2.013$; c) $t(B*C)=1.378<t(32, 0.05)=2.037$. This indicates that correlation coefficients between the three populations are not significantly different ($p<0.05$). The *t*-test, however, has proven the significant differences between these intercepts ($t(A*B)=0.850<t(45, 0.05)=2.014$, $t(A*C)=7.591>t(45, 0.001)=3.5205$, $t(B*C)=6.138>t(32, 0.001)=3.622$). The differences in intercept are obvious between *C.* daisuce and *C. leptus* and this will account for the shorter tail in *C. daisuce.*

It seems likely that tail length of *C. leptus* is determined by two different elements, *i.e.* a constant of the tail itself and another element dependent on the L′, each of which may have its own variance. Strictly speaking, these relatively low correlation coefficients, which give rather low coefficients of determination (r^2), are insufficient to account for even the proportional elements on L′. As a consequence, the tail length of *C. leptus* will be considered as relatively stable within a certain range even under the influence of the L′. The fairly long tail in all nominal *C. leptus* (usually more than 200 μm) may be due to certain constants of the tail itself, as suggested by the fairly high intercepts in the regression lines. However, unlike *C. leptus,* tail

length of *C. daisuce* appears to be a function of the L′.

(3) *Correlation related to Ratio-V′*: Ratio-V′ in most cases offers a good yardstick for nematode taxonomy. The validity of this ratio depends solely on the strong positive correlation between the distances VL and L′. And in this case the regression line as such appears a good taxonomic character. By the regression analyses of VL (Y) on L′ (X), the following are obtained:

(A) $Y=10.3+0.816X$, $r=0.993$, $p<0.01$ (*C. leptus* from Hokkaido: n=31)

(B) $Y=14.0+0.797X$, $r=0.987$, $p<0.01$ (*C. leptus* from Nagano: n=18)

(C) $Y=-7.6+0.865X$, $r=0.992$, $p<0.01$ (*C. daisuce*: n=18)

Differences between the regression coefficients of the three were tested by a t-test as mentioned before. Results are as follows: a) $t(A*B)=0.581<t(47, 0.05)=2.012$; b) $t(A*C)=1.336<t(47, 0.05)=2.012$; c) $t(B*C)=1.428<t(32, 0.05)=2.037$. All three regression coefficients between the three populations are not significantly different ($p<0.05$). However, the regression line of *C. daisuce* (C) can not be safely regarded as parallel to those of the populations from Hokkaido (A) and Nagano (B) as the values in t-test are larger than 1.3 ($p<0.20$; $t(47, 0.2)=1.300$ and $t(32, 0.2)=1.309$ respectively).

(4) *Number of Annules*: Number of body annules excluding tail (referred as R-an, which is distinguished from real Ran) is often used to distinguish species. However, RASKI & GERAERT[9] measured the annules width in the various body part of a *C. leptus* population, stated that "variability in body annule width suggests the width and consequently number of annules, are not a sufficient basis to distinguish species". By correlation analysis between mean annule width and number of annules in a population, I attempted to show whether the mean annule width influences the R-an. Results are as follows:

$r=-0.076$, $p>0.05$ for Hokkaido population (n=25)

$r=0.195$, $p>0.05$ for Nagano population (n=7)

There are no significant negative correlations between mean annule width and R-an so far as Japanese populations are concerned. This apparently results from the positive correlation between the L′ and R-an; *i.e.* for the Hokkaido population, $r=0.440$, $p<0.05$ (n=25) and for Nagano population, $r=0.911$, $p<0.01$ (n=7). These results indicate that the R-an is not influenced by the mean annule width but by the body length.

B. Relationship of C. leptus with C. daisuce: RASKI & GERAERT[9] have commented on *C. daisuce* as "difficult to differentiate from *C. illustris*, with which it has not been compared" (*Note added in proof*). Indeed *C. daisuce* has a finely rounded tail tip and a short tail, which suggests *C. illustris*, yet *C. daisuce* differs from *C. illustris* by the decidedly narrower head (4.7−5.5 μm in *C. daisuce vs.* 6−7 μm in *C. illustris*), lower head (2−3 μm *vs.* 3.0−3.5 μm), lower V-value (55.4−62.2 (58.4±1.6) *vs.* 64.5−69.5), lower V′-value (83.6−85.5 (84.6±0.5) *vs.* 86−87.5) and lower c-value (2.9−3.8(3.2) *vs.* 4−5).

In the original description, MIZUKUBO & MINAGAWA[5] noted the close relationships between *C. daisuce, C. limichus* and *C. leptus*. The increasing information of the variability of *C. leptus* makes it difficult to separate *C. daisuce* from *C. leptus*, although *C. daisuce* is still distinguishable from *C. leptus* by some differences. This species may be better understood as a subspecies of *C. leptus*. The reasoning is as follows:

(1) There are few distinctive qualitative differences. a) Lip regions commonly have three annules, and the shapes are similar (I have not examined the SEM surface view). b) Spear knobs described as rounded in *C. daisuce* also frequently arise in *C. leptus*, and angular knobs are found in *C. daisuce* as well. c) *C. daisuce* has a cuticularized excretory pore duct, which was not observed in the *C. leptus* of Japan and has not been mentioned in ANDRÁSSY's description[1]. However, SIDDIQI[11] and RASKI & GERAERT[9] reported cuticularized ducts. Consequently there is no certainty to this character. d) Basal esophageal bulb as drop-shaped and offset from intestine

Table 2. Matrices of coefficients of difference of V′ and VL between six *Cephalenchus* populations.

n	Shawnee 10	Guanella 5	Loomis 12	Hokkaido 31	Nagano 18	*C. daisuce* 18
Shawnee, CO, USA		0.209 −	0.193 −	0.554 −	0.408 −	0.886 +
Guanella Pass, CO, USA	0.126 −		0.042 −	0.681 +	0.407 −	1.356 ++
Loomis, CA, USA	0.256 −	0.326 −		0.444 −	0.273 −	0.885 +
Hokkaido, Japan	0.788 +	0.743 +	0.583 −		0.127 −	0.509 −
Nagano, Japan	1.061 +	0.958 +	0.867 +	0.251 −		0.552 −
C. daisuce Japan	1.732 ++	1.456 ++	1.545 ++	0.761 +	0.479 −	

V′

VL

C.D. corresponds to percentage of nonoverlap of partially overlapping curves, which is indexed as:
− : below 0.675 (less than 75 % of a population will be different from same percentage of individuals of the compared population).
+ : between 0.675 and 1.27 (each 75 to 89 % of individuals of two population will differ, satisfying the 75-percent rule for subspecies recognition).
++ : 1.28 or more (each 90 to 100 % of individuals of two population will differ, satisfying the 90-percent rule for subspecies recognition).

Table 3. Matrices of coefficients of difference of tail and excretory pore between six *Cephalenchus* populations.

n	Shawnee 10	Guanella 5	Loomis 12	Hokkaido 31	Nagano 18	*C. daisuce* 18
Shawnee, CO, USA		0.215 −	0.878 +	0.919 +	1.089 +	2.200 ++
Guanella Pass, CO, USA	0.247 −		0.587 −	0.561 −	0.709 +	1.745 ++
Loomis, CA, USA	0.239 −	0.000 −		0.151 −	0.003 −	1.158 +
Hokkaido, Japan	0.780 +	0.485 −	0.468 −		0.191 −	1.574 ++
Nagano, Japan	1.556 ++	1.199 +	1.152 +	0.777 +		1.407 ++
C. daisuce Japan	1.533 ++	1.239 +	1.198 +	0.908 +	0.332 −	

Tail

Excretory Pore

+, +, ++ : refer to Table 2.

in *C. daisuce* can not be fully distinguished from that of *C. leptus,* since the basal bulb of the latter vary from lobed to well offset, and the shape as such (cylindrical or pear-shaped) is quantitative in nature. e) Hemizonid is same level or immediately posterior to excretory pore in both *C. daisuce* and *C. leptus.* f) The R-an reported for *C. daisuce* (229−248 (238)) agrees to that for *C. leptus* in Japan (220−253 (233 in mean)). g) Finally, finely rounded tail tip seldom occurs in *C. leptus.* This is an only obvious qualitative character-state to differentiate *C. daisuce* from

Table 4. Comparison of measurements of *C. leptus*, *C. limichus* and *C. daisuce*.

Criteria	*C. leptus*			*C. limichus*	*C. daisuce*
	ANDRÁSSY	R & G	Japan	ANDRÁSSY	M & M
esophagus (μm)	98−106*	90−116 (104−112)**	83−121 (97−107)	108−114	84−114 (95)
b	6.0−7.0	6.1−7.8 (6.6−7.1)	5.7−7.7 (6.4−6.6)	5.4−6.3	5.1−6.5 (6.0)
tail (μm)	216−236	178−282 (221−253)	198−262 (220−233)	176−194	135−201 (176)
c	2.8−3.3	2.6−3.6 (2.9−3.1)	2.7−3.2 (2.9)	2.9−3.4	2.9−3.8 (3.2)
V′	83.1#	82−87 (83)	80.6−84.8 (83.5−84.0)	85.7#	83.6−85.5 (84.6)
annules(mid-body) (μm)	2.0−2.3	—	1.5−2.1 (1.7−1.9)	1.4−1.5	1.4−1.9
annules(L′/R-an) (μm)	—	1.6−2.5	1.68−2.08 (1.85)	—	1.49−1.87 (1.66)
R-an	212−218	—	220−253 (233)	278−284	229−248 (238)
hemizonid/ ex. pore in annule.	just posterior	near	same level or just posterior	1 or 2 anterior	same level or just posterior

* range. ** range of mean. # calculated from figures.

C. leptus.

(2) As has been examined, a quantitative differences between *C. daisuce* and *C. leptus* is the tail length. The regression line of *C. daisuce* is significantly different from those obtained in *C. leptus* from Japan at least in the much lower intercept, which accounts for the shorter tails of *C. daisuce*.

The coefficient of difference (C.D.) is a simple method to distinguish the populations. In order to examine the difference between *C. daisuce* and *C. leptus*, C.D. of the ratio-V′, VL, tail and esophagus between six populations including the populations from the United States are calculated (Tables 2 & 3). Accurate means of the V′-values for populations from the United States are not available, and are estimated by calculating their VL and V-a means, *i.e.* 82.8 for Shawnee, 83.2 for Guanella Pass and 83.3 for Loomis respectively.

The matrices show that *C. daisuce* is among the most distinctive in tail length, although this population overlaps with the Nagano population in other dimensions. The remaining five populations are not distinctive except for the excretory pore distance between the Shawnee and the Nagano populations.

This analysis is useful only when a sufficiently large number of individuals are observed. Since the samples used here do not satisfy this requirements, we can not draw conclusion from the results, which, however, confirm the scarce overlaps between *C. leptus* and *C. daisuce* in the tail length (Table 4). As a consequence, *C. daisuce* is distinctive from *C. leptus* only in tail length and the generally finely rounded tail tip. These character-states, for the present, are difficult to be regard as an extremity in the possible cline in *C. leptus*. This population is therefore considered as a subspecies of *C. leptus*:

Cephalenchus leptus daisuce (MIZUKUBO & MINAGAWA, 1985) n. rank

Syn. *Cephalenchus daisuce* MIZUKUBO & MINAGAWA, 1985

C. Relationship of C. leptus with C. limichus: RASKI & GERAERT[9] synonymized *C. limichus* with *C. leptus*. They showed that the gaps in the dimensions, *i.e.* esophagus length, b-value and tail length on which ANDRÁSSY[1] distinguished the two species were bridged by overlapping in the

three populations from the United States except for annule width and number. Dimensional data of the Japanese *Cephalenchus* populations also show bridged overlaps covering gaps in the mentioned characters but leave an evident gap in the average width and number of annules (Table 4).

Distinction between the *C. limichus* and *C. leptus* is discussed below.

(1) Results in examination of the ratio-b confirm that the high variability of esophagus length (83−121 μm) in *C. leptus* is independent of the body length. Distinction of the two species by b-value is not justified.

(2) Results in the examination of tail measurements justify the separation of *Cephalenchus* populations by the evident gaps in the tail length. Although length of the tails of *C. leptus* vary considerably (178−282 μm), the mean length constantly exceeds 200 μm (220−253 μm). An extremely long tail, over 200 μm, is considered a common character-state of *C. leptus leptus*. On the contrary, the range of tail dimension of *C. limichus* can not be properly determined. Note that the *C. limichus* reported by ANDRÁSSY from Colorado[1] have rather short tails (176−194 μm) which never exceed 200 μm, whereas the original *C. limichus* reported by NESTEROV[6] are larger (L=650−740 μm) with a smaller c-value (2.9−3.2), which led to tails decidedly longer than 200 μm. It is unknown if the tails of *C. limichus* have a wide range of variability or the two different populations are not conspecific. Separation of *C. limichus* by tail length is currently difficult.

(3) Strict comparison of number of annules is impossible for the present. Body annules (R-an) of the two Japanese populations of *C. leptus* are similar (220−253, 233 in mean). ANDRÁSSY[1] reported apparently fewer annules (212−218) in the same species. The slight gaps in number can be interpreted as possible intraspecific variation, since the annules in esophageal region are 53, 49−50, 59 and 49−62(53−54 in means) respectively in the original description[11], ANDRÁSSY[1], RASKI & GERAERT[9] and the Japanese populations. This suggests that R-an of most populations is close to my observation of Japanese populations. Japanese populations show a C.V. of 3.6 (233±8.5 in number) for R-an, which suggests the counts of annules in the species will not be so variable. Further, the R-an is influenced by the L′ as seen before. If this is true of all *C. leptus* populations, larger number of R-an must be held by larger individuals, *i.e.* the specimens of ANDRÁSSY (*C. limichus*), which has R-an of 278−284 must be fairly large individuals. The fact is that ANDRÁSSY described shorter body length (610−630 μm) for his specimen of *C. limichus* from Colorado; while we can measure 580−830 μm for *C. leptus*. Counts of R-an can not be rejected when distinguishing *C. leptus* and *C. limichus*.

(4) RASKI & GERAERT[9] pointed out that annule width of *C. leptus* vary in different body regions. This is also true of the Japanese populations: mid-body annules are rather narrow (1.5−2.1 μm in range and 1.7−1.9 μm in means) as in the population from Guanella Pass (1.6−1.8 μm). Apparently average width of body annule appears more useful for comparison. Dividing the L′ by R-an, wider measurements (1.7−2.1 μm) are obtained in the Japanese populations. Likewise, I have calculated "1.55 μm" as the average width of body annule in *C. limichus*. Apparently there is no bridge of ranges between *C. leptus* and *C. limichus*. I have already shown that average width of body annule has not been influenced by the body length nor the number of annules (R-an). Thus the average width of body annule appears useful to distinguish *C. limichus* and *C. leptus*.

(5) There remains an important character-state that was not mentioned by ANDRÁSSY[1] in his diagnostic remark of *C. limichus* and *C. leptus*: *i.e.* the relative position of the hemizonid to the excretory pore (immediately posterior to the latter (ANDRÁSSY[1]), same level or immediately posterior (Japan), merely mentioned "near" (RASKI & GERAERT[9]), or one and two annules anterior (*C. limichus*[1])). This character appears useful since the relative position of the hemizonid and the excretory pore is stable in all the Japanese *Cephalenchus* populations.

It is finally concluded that *C. limichus* is separated from *C. leptus* by the narrower annules, more numerous annules and relative position of hemizonid, and synonymization of *C. limichus*

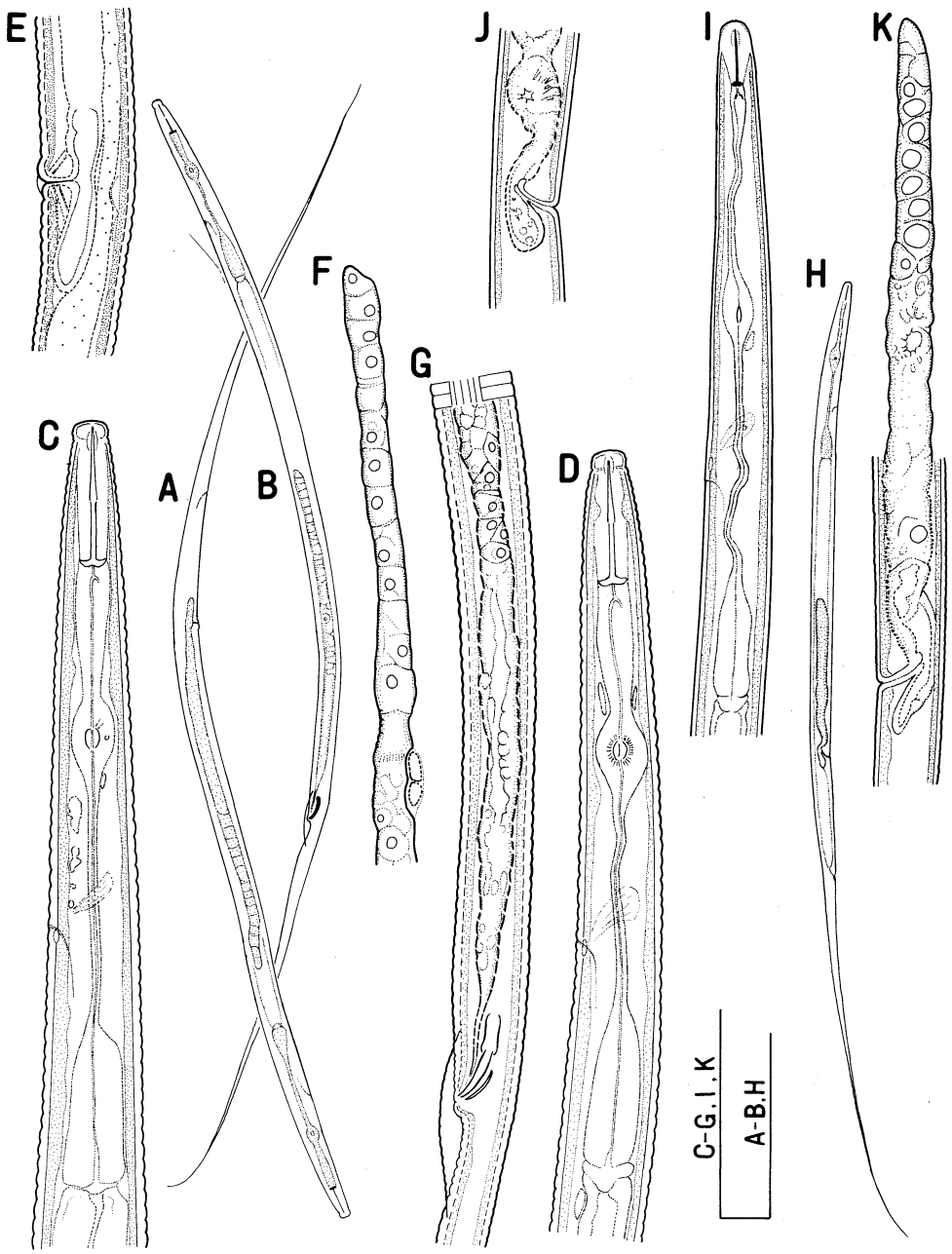

Fig. 2. *Cephalenchus leptus leptus* (A-G) and *Lelenchus leptosoma* (H-K) from Japan. A, full length (female); B, full length (male); C, esophageal region (female); D, esophageal region (male); E, vulval region; F, anterior part of testis; G, posterior part of testis (continued from F) and cloaca; H, full length; I, esophageal region; J, vulval region; K, gonad. Scales: A, B and H, 100 μm; C-G, I and K, 30 μm.

with *C. leptus* is currently not justified.

Cephalenchus leptus leptus (SIDDIQI, 1963) n. rank
Syn. *Cephalenchus leptus* (SIDDIQI, 1963) KNOBLOCH, 1972
(Fig. 2 A-G; Table 5)

Morphometric relationships of the three populations of *Cephalenchus* in Japan with those of *C. leptus* reported by SIDDIQI[11], ANDRÁSSY[1] and RASKI & GERAERT[9] are discussed, and the differences between the populations are presented (Tables 2, 3, 4 & 5). They are nominated subspecies of *C. leptus,* proposed here as *C. leptus leptus,* and are separated from *C. leptus daisuce* as discussed before. A description based on the Hokkaido population is given below.

Females (n=31): Body slightly bent ventrally when killed by gentle heat (Fig. 2 A). The

Table 5. Measurements of three populations of *Cephalenchus leptus leptus.*

Criteria	Tomuraushi (Hokkaido)			Osoushi (Hokkaido)		Nagano	
	females		male	females		females	
n	31		1	7		18	
L (μm)	592−737	(660±37.2)*	620	649−750	(683)**	578−740	(644±38.0)*
L′ (μm)	374−484	(432±29.6)	393	419−494	(450)	366−471	(423±29.2)
a	33.9−51.6	(43.0±4.5)	44.8	40.9−50.2	(45.6)	37.6−49.0	(44.8±2.5)
b	5.7−7.7	(6.4±0.48)	6.1	6.1−6.8	(6.4)	5.7−7.3	(6.6±0.45)
c	2.7−3.2	(2.9±0.13)	2.7	2.8−3.1	(2.9)	2.7−3.1	(2.9±0.12)
c′	18.8−27.6	(23.5±2.4)	31.3	20.7−27.8	(24.1)	22.0−28.3	(24.8±2.0)
V	53.0−58.0	(55.2±1.3)	—	53.8−57.1	(55.2)	52.7−56.1	(54.5±1.0)
V′	82.1−84.8	(84.0±0.7)	—	82.3−84.7	(83.8)	80.6−84.1	(83.0±0.9)
VL (μm)	314−407	(363±24.3)	—	353−414	(377)	305−390	(351±23.5)
Gl or T	17.0−37.9	(29.8±4.9 : n=27)	29.4	23.1−31.9	(27.6)	21.8−32.1	(29.5±3.1 : n=10)
spear (μm)	15.8−19.1	(18.3±0.6)	18.5	17.8−19.1	(18.6)	15.8−17.8	(17.1±0.5)
oesoph. (μm)	83−112	(104±5.51)	102	100−121	(107)	87−110	(97.4±5.3)
MB	36.2−43.8	(40.4±1.6)	41.3	36.6−41.8	(40.4)	34.5−45.8	(40.7±2.7)
ex. pore (μm)	64−77	(70.5±3.2 : n=23)	69.3	65−87	(73.3)	63−73	(66.4±2.2)
E.P.	9.9−11.5	(10.8±0.4 : n=21)	11.2	9.6−11.5	(10.7)	9.4−11.5	(10.3±0.6)
Vulva-anus (μm)	60−83	(69.4±6.1)	—	66−81	(72.9)	61−86	(72.2±7.0)
tail (μm)	207−262	(226±13.0)	227	212−256	(233)	198−237	(220±13.2)
Tail/V-a	2.7−3.8	(3.3±0.27)	—	2.9−3.5	(3.2)	2.4−3.5	(3.1±0.30)
annule width. (μm)	1.5−2.1	(1.8±0.14)	1.5	1.7−2.1	(1.9)	1.5−1.9	(1.7±0.13)
annule(L′/R-an) (μm)	1.68−2.08	(1.85±0.12)	—	—	—	1.84−1.93	(1.90±0.02 : n=7)
p.u.s. (μm)	13−21	(16.5±1.6)	—	15.2−19.1	(17.0)	11.1−16.6	(14.3±1.5)
U	0.9−1.4	(1.2±0.13)	—	1.0−1.4	(1.2)	0.7−1.5	(1.1±0.16)
spear/head diam.	3.1−3.7	(3.4±0.19)	3.7	3.2−3.6	(3.5)	3.1−3.8	(3.5±0.17)
conus/spear	46.3−52.7	(48.9±1.9)	48.2	47.3−50.0	(48.7)	45.5−52.4	(48.4±2.2 : n=11)
lfw/body diam.	31.0−45.8	(38.7±4.1)	38.1	26.0−39.0	(33.4)	33.3−47.1	(37.4±3.5 : n=15)
Rex	35−44	(39.3±2.2 : n=23)	41	39−44	(41.1)	38−43	(40.0±1.9 : n=12)
ROes	49−62	(55.6±3.5 : n=24)	—	—	—	49−57	(52.9±3.2 : n=8)
RVan	33−43	(37.6±2.9)	—	35−41	(37.0)	36−45	(39.8±3.1 : n=13)
RV	183−211	(195±6.9 : n=25)	—	—	—	181−202	(192±6.7 : n=7)
R-an	220−253	(233±8.5 : n=25)	—	—	—	222−244	(233±8.4 : n=7)
spicule (μm)	—	—	13.9	—	—	—	—
gubernaculum. (μm)	—	—	4.3	—	—	—	—

* range (mean±SD). ** range (mean).

widest diameter mostly at the esophagus end, equal to or very slightly reduced toward the vulva, then tapers gradually to the fine tail terminus. Lateral fields 5.8 μm±0.89 (n=24) wide, slightly more than 1/3 as wide as body width, with six equally spaced incisures.

Lip region balloon-like, 5.0−5.9 μm wide 2.3−3.0 μm high, constricted from neck, bearing three annules. Spear very slender, conus as long as shaft; basal knobs 3.3−4.6 μm wide, considerablely varies in shape, broadly rounded and flattened anteriorly or angular at edges, not inclining posteriorly. Dorsal gland orifice 0.5−3.0 μm behind spear base. Procorpus length varies considerably, 1.1 times ±0.19 as long as spear; metacorpus oval to spherical, 10.6 μm±0.61(n=28) long and 6.8 μm±0.59(n=27) wide, valve conspicuous, lying before the middle of esophagus; isthmus narrow, 32.2 μm±3.94(n=25); basal bulb somewhat cylindrical and elongate, 24.0 μm±2.4(n=25) long decidedly shorter than isthmus and well set off from both isthmus and intestine, its posterior margin sometimes slightly lobed. Excretory pore usually immediately before the hemizonid, rarely same level as the latter, located near the middle of isthmus, 67% ±4.1(n=25) of esophagus, its duct inconspicuous. Hemizonid 1−1.5 annule long. Deirids at the third to the fifth annule posterior to excretory pore.

Vulval lips large and slightly protruded, vulval flaps (or dikes) conspicuous, 5.7 μm±0.72 (n=8) long (Fig. 2 E). Vagina tubular and usually perpendicular to body axis, very rarely directed anteriorly, 5.6 μm ±0.71(n=28) long and 39.5 %±4.6(n=28) of vulval body diameter. Spermatheca hardly observed. Post-uterine branch slightly longer than vulval body diameter. Phasmids can not be detected. Tail slender and straight, exceeding 200 μm with very rare exceptions, tips finely pointed or hair-like.

Male (n=1): General morphology agrees well with female. Body slightly bent ventrally

Table 6. Comparison of measurements of five populations of *Lelenchus leptosoma*.

Criteria	Nagasaki (female)			Nagano (female)		Orange Bay	Colorado	Alaska
	range	mean±SD	C.V.	range	mean	mean±SD	mean±SD	mean±SD
n		20		3		10	11	5
L (μm)	457−540	(506±21.2)	4.2	517−560	(543)	639±75	621±65	571±126
L′ (μm)	314−349	(331±9.91)	3.0	347−366	(314)	—	—	—
a	39.4−54.0	(47.1±3.0)	6.3	51.5−55.8	(53.2)	56±4.15	55±5.13	57±7.85
b	4.8−5.9	(5.3±0.23)	4.3	5.2−5.4	(5.3)	6.2±0.50	5.6±0.22	5.5±0.59
c	2.7−3.4	(2.9±0.21)	7.3	2.7−3.0	(2.9)	3.0±0.25	2.5±0.84	2.9±0.29
c′	20.2−29.9	(27.0±2.6)	9.7	28.1−30.6	(29.2)	30.0±4.91	28.9±2.91	35±10.08
V	48.8−54.8	(50.6±1.7)	3.3	49.1−51.9	(50.6)	50.2±1.21	49.9±1.47	50±2.67
V′	75.6−78.5	(77.4±0.7)	0.9	77.3−78.0	(77.6)	76±2.17	76±0.84	(75−76)##
VL (μm)	241−271	(256±8.36)	3.3	268−285	(275)	321±38.22	310±29.37	264±16.52
G1 or T	11.7−22.1	(18.1±2.5)	13.5	18.5−24.0	(21.7)	—	—	—
spear (μm)	7.6−8.6	(8.1±0.25)	3.2	8.1−8.6	(8.3)	9.0±1.12	(8−10)##	(7−8)##
esophagus (μm)	90−98	(94.6±2.0)	2.1	99−104	(101)	103±7.06	112±9.91	97±3.75
MB	40.1−45.3	(42.0±1.1)	2.7	42.0−43.9	(42.8)	—	—	—
ex. pore (μm)	62−68	(65.2±1.5)#	2.3	65−74	(70.0)	77±6.89	81±6.42	68±0.87
E.P.	12.4−14.5	(13.0±0.6)#	4.5	12.5−13.2	(12.9)	—	—	—
Vulva-anus (μm)	69−81	(74.9±3.0)	4.0	79−81	(79.4)	101±21.76	95±8.96	85±7.25
tail (μm)	133−193	(175±17.1)	9.7	170−202	(189)	219±29.82	216±30.24	184±43.35
Tail/V-a	1.7−2.7	(2.3±0.26)	11.0	2.2−2.6	(2.4)	—	—	—
annule width (μm)	0.7−1.0	(0.9±0.07)	8.1	0.8−0.9	(0.9)	—	—	—
p.u.s. (μm)	5.3−12.5	(8.4±1.98)	23.7	9.2−11.2	(10.3)	—	—	—
U	0.6−1.3	(0.9±0.21)	24.4	0.9−1.2	(1.1)	—	—	—
spear/head diam.	1.8−2.2	(2.0±0.12)	5.8	1.9−2.2	(2.0)	—	—	—

n=18.　　## range.

when killed by gentle heat (Fig. 2 B). The widest body diameter at the end of esophagus, very slightly tapers toward cloaca, then abruptly narrowed and broadened at the posterior margin of bursa, again evenly tapers to fine tip of tail.

Lip region 5.0 μm wide and 2.6 μm high. Spear knobs 4.3 μm wide followed by D.G.O. 1.7 μm behind. Procorpus as long as spear; metacorpus 7.3 μm wide and 11.2 μm long; isthmus 29.7 μm long; basal bulb cylindrical, offset, 24.4 μm long. Excretory pore level with the hemizonid, 68 % of esophagus. Deirids at the fifth annule behind the excretory pore.

Testis outstretched showing no reflex anteriorly, anterior cellular portion arranged in single row. Both bursae equal in length, 25 μm long, *i.e.* 3.5 times of anal body diameter, weakly crenate on margins, almost symmetrical. Spicule tylenchoid, ventrally curved; gubernaculum thin, simple and trough-shaped.

Specimens examined: 31 females, 1 male, Tomuraushi, Shintoku-machi, Hokkaido, Japan, 24. vi. 1986, leg. T. MIZUKUBO, soil around the root of *Acer mono* var. *marmoratum*; 7 females, Osoushi, Shintoku-machi, Hokkaido, 22. vi. 1986, leg. T. MIZUKUBO, soil around the root of an herbaceous plant; 18 females, Komoro City, Nagano, Japan, 22. x. 1987, leg. T. MIZUKUBO, soil around the root of an unidentified tree. Materials are deposited at the Herbarium and Insect Museum of the NIAES.

Lelenchus leptosoma (DE MAN, 1880) MEYL, 1961

(Fig. 2 H-K; Table 6)

Twenty females of *L. leptosoma* collected by the author from forest soil near Todoroki-no-taki, Takagi-machi, Nagasaki (Kyushu: Japan) and three females from Komoro City, Nagano (Honshu: Japan) were studied. Morphology and morphometrics agree well with those given in RASKI & GERAERT[8], although they are slightly shorter and are apparently parthenogenetic populations. As early as 1931, IMAMURA[4] had reported *Tylenchus leptosoma* DE MAN, 1880 from Japan, which apparently is not conspecific nor congeneric with *L. leptosoma* as has been suggested by RASKI & GERAERT[8]. Accordingly, the present record is the first report of the species in Japan.

Morphometrics are given in Table 6.

Remarks: Correlation analyses were made on the ratios c, MB, V and V′ and a regression line was determined for VL on L′. Results are as follows.

(1) Ratio-c: Correlation between tail length and length of body trunk (L′) is not significant ($r=0.175$, $p>0.05$, n=20).

(2) Ratio-MB: Correlation between distance of esophageal length and distance from anterior end to valve of metacorpus is not significant ($r=0.278$, $p>0.05$, n=20).

(3) Ratio-V: Correlation between VL and L is positive and significant ($r=0.653$, $p<0.01$, n=20).

(4) Ratio-V′: Correlation between VL and L′ is strongly positive and significant ($r=0.961$, $p<0.01$, n=20). Regression line of VL (Y) on L′ (X) is calculated as: $Y=-15.930+0.821X$.

These results show that the c-value and MB-value are meaningless as a yardstick of *Lelenchus leptosoma,* and suggest that V-value is also unreliable to distinguish species, rather V′-value should be used. Results also agree with observations by GERAERT[2], except for ratio-c.

Materials are deposited at the Herbarium and Insect Museum of the NIAES.

LITERATURE CITED

1) ANDRÁSSY, I. (1984) The genera and species of the family Tylenchidae ÖRLEY, 1880 (Nematoda). The genera *Cephalenchus* (GOODEY, 1962) GOLDEN, 1971 and *Allotylenchus* gen. n. Acta Zool. Hungar. **30**, 1-28.

2) GERAERT, E. (1968) Morphometric relations in nematodes. Nematologica **14**, 171-183.

3) GERAERT, E. & RASKI D. J. (1988) Study of some *Aglenchus* and *Coslenchus* species (Nemata: Tylenchida). Nematologica **34**, 6-46.

4) IMAMURA, S. (1931) Nematode in the paddy field, with notes on their population before and after irrigation. Jour. Coll. Agric., Imperial Univ. Tokyo **11**, 193-240.
5) MIZUKUBO, T. & MINAGAWA, N. (1985) Taxonomic study of the genus *Cephalenchus* (Nematoda: Tylenchida) from Japan. Descriptions of three new species and records of *C. planus* SIDDIQUI & KHAN with a key to species. Jpn. J. Nematol. **15**, 26-40.
6)* NESTEROV, P. I. (1973) (New species of plant nematodes from the rhizospheres of cultivated and wild plants in Moldavia, USSR). Kishinev, USSR: Izdatel'stvo "Shtiintsa". Parazity Zhivotnykh i Rastenii **9**, 239-246.
7) PHUKAN, P. N. & SANWAL, K. C. (1980) Two new species of *Aglenchus* and record of *Cephalenchus leptus* (Tylenchida: Nematoda) from Assam. Indian J. Nematol. **10**, 28-34.
8) RASKI, D. J. & GERAERT, E. (1986) New species of *Lelenchus* ANDRÁSSY, 1954 and *Ecphyadophora* DE MAN,, 1921 (Nemata: Tylenchidae) from southern Chile. Nematologica **31**, 244-265 (1985).
9) RASKI, D. J. & GERAERT, E. (1986) Description of two new species and other observations on the genus *Cephalenchus* GOODEY, 1962 (Nemata: Tylenchidae). Nematologica **32**, 56-78.
10) SEINHORST, J. W. (1959) A rapid method for the transfer of nematodes from fixative to anhydrous glycerin. Nematologica **4**, 67-69.
11) SIDDIQI, M. R. (1963) Four new species of the genus *Tylenchus* BASTIAN, 1865 (Nematoda) from North India. Z. Parasitenk. **23**, 170-180.
*indirect citation

Accepted for publication: July 21, 1989

和文摘要

Aglenchus ainakamurae(新種)の記載および *Cephalenchus leptus* ならびに *Lelenchus leptosoma* の記録

水久保隆之

ハリセンチュウ科の3種、*Aglenchus ainakamurae*（新種）、*Cephalenchus leptus leptus* および *Lelenchus leptosoma* を日本から記録した。1）*A. ainakamurae* は茨城県御前山村のサンショウ・イロハモミジ・ハギ属の一種およびイラクサ属の一種から検出された。本種は近似する *A. muktii* とは雄がいないこと、毛状の尾端および先細になった唇部側面像によって区別される。また本種は、雄の欠如・先細の唇部・体環数・MB・c・V・V'等の値の相違に基づき *A. geraerti*（新名）と区別される。2）*C. leptus leptus* の個体群を、イタヤカエデ、草本（北海道）および未同定木本（長野県）から分離し、再記載した。国内の *C. leptus* の計測値を分析した結果から、*C. leptus* の異名同物とされた *C. limichus* を有効種と考え、日本から記載された *C. daisuce* を *C. leptus* の一亜種（*C. leptus daisuce*）に位置づけ、同時に *C. leptus* を承名亜種（*C. leptus leptus*）とした。3）長崎県及び長野県の森林土壌から分離した *L. leptosoma* を図示し、諸計測値を示した。*Aglenchus* 属と *Lelenchus* 属はそれぞれ日本最初の報告である。